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SENSIBILITY OF THE INVASIVE SNAIL MELANOIDES TUBERCULATUS (MÜLLER, 1774) TO SALINITY VARIATIONS

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INTRODUCTION

Estuaries are among the most productive
systems in coastal zones, but they are also
among the most impacted (Kennish, 2002).
Human activities, including chemical pollu-
tion, nutrient enrichment, overexploitation of natural resources and changes in hydrologi-cal regimes, can have a number of effects on estuarine regions. In the last decades, the introduction of alien species has also been reported as an important source of degradation of estuaries (Kennish, 2000, 2002).
Almost all estuaries are affected to some extent by the introduction of invasive spe-cies (Carlton, 1989; Carlton & Geller, 1993). Bioinvasions may lead to changes in habitat and trophic organization, a reduction in spe-cies diversity, the spread of pathogens, and in extreme cases, the total displacement of na-tive species (Carlton, 1996; Ehrenfeld, 2010; Simberloff et al., 2013).
Despite all of the potential difficulties imposed by a new habitat, invasive species are suc-cessful in colonizing new environments due to environmental characteristics (invasibility) and those of the invasive species (invasiveness) (Lodge, 1993; Alpert et al., 2000; Colautti et al., 2006).
Among invasive macroinvertebrates, a group of great importance is the Gastropoda (Carlton, 1999). Melanoides tuberculatus (Müller, 1774) is a gastropod that has invaded lakes, rivers and estuaries around the world (Bolaji et al., 2011; Roessler et al., 1977). It is typically a freshwater species, but it can also inhabit brackish waters (Wingard et al., 2008) and is the invasive species with the widest distribution in Brazil (Silva & Barros, 2011). However, there
is only one report of this species in Brazilian brackish water (Barroso & Matthews-Cascon, 2009). There is substantial evidence that in-vader success is related to fast growth and a

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high rate of reproduction, but enhanced stress tolerance is also important (Weir & Salice, 2011). Previous studies have observed that M. tuberculatus is tolerant to several natural and anthropogenic abiotic stressors (Weir & Salice, 2012), but the salinity tolerance of this invasive species is still unknown.
The colonization of new habitats poses chal-lenges to invaders (Richardson et al., 2000), especially in estuarine areas, mainly due to changes in salinity. However, invasive spe-cies have characteristics that favor and help overcome these challenges. Thus, this study aims to evaluate the resistance of the invasive snail, M. tuberculatus, to salinity.

MATERIALS AND METHODS

Specimens of M. tuberculatus (Fig. 1) were collected at four different freshwater sites around Salvador City, Bahia in northeast Brazil (PMP’s lake — 12°58’02”$, 38°24’43”W; Passa Vaca River — 12%57'42”S, 38°24’00”W; Stella Maris Lake — 12°55’58”$, 38*19'"34”W; and Flamengo's Lake — 12°55’31”$, 38*19'10"W) and acclimatized in an aquarium with sand and macrophytes (Salvinia auriculata and Egeria densa) for 72 h.
Two salinity tolerance experiments were conducted in the laboratory. The experiments consisted of exposing the M. tuberculatus test organisms to different salinities (5, 10, 15, 20, 25, 30, 35, 40 and 45, experiment 1; n = 5) for 48 h. |
In the second experiment, all organisms were initially placed into aquaria supplied with fresh-water (n = 15). Five aquariums were maintained with freshwater for six weeks (treatmenAt) , five were subjected to weekly increases in salinity (five per week) (treatment B), and the last five were subjected to higher weekly increases in salinity (eight per week) (treatment C).

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To assess salinity tolerance (experiment 1), one-way ANOVA between survival (%) and nine treatments was performed (followed by Tukey’s test). To assess the resistance of the organisms to gradual increases in salinity (ex-periment 2), one-way ANOVA was performed followed by Tukey’s test between treatments after six weeks.

RESULTS

In experiment 1, we observed that most organisms survived until reaching a salinity of 25 (only 4% mortality) and that the survival rate remained relatively high (74%) until 30 (Fig. 2). The analysis of variance showed sig-nificant differences between treatment means (p < 0.001). The comparison between paired treatments (Tukey’s test) revealed the follow-ing: 505 = $10 = $15 = $20 = S25 À $30 7
$35 = $40 = S45.
Experiment 2 showed that all treatments
led to decreases in survival, especially those
above 25 to 30 (five weeks), which resulted in
sharp decreases in survival. However, even in
1 cm extreme salinities (i.e., 45 in treatment C after
six weeks), the mean survival rate was greater
than 50%, indicating that this species is able
FIG. 1. Melanoides tuberculatus from Salvador, to survive in hyperhaline conditions (Fig. 3). Bahia, Brazil. The ANOVA results showed significant dif-

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A 40%-

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5 10 15 20 25 30 35 40 45
Salinity

FIG. 2. Survival rate of Melanoides tuberculatus exposed to various salinity concentrations. The hori-zontal dashed line indicates 50% survival. Some points overlap on the graph (n = 5).

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Weeks

FIG. 3. Average M. tuberculatus survivors per week for the three treatments (А, В and С; п = 5). А = water was maintained at < 5 salinity (control); В = weekly increase in salinity of 5; С = weekly increase in salinity of 8.

ferences between the treatment means (p organism because their survival decreased < 0.001) and differences between all paired following most oft he saline treatments tested; treatments (AB, p < 0.01; BC, p < 0.001; and however, resistance to polyhaline conditions AC; p < 0.001) (Fig. 4). Thus, we suggest of up to 30 was observed without great dif-that salinity can influence the survival of this ficulty.

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Treatments

FIG. 4. Graph of the analysis of variance of the number of individuals versus the treatments. Some points overlap on the graph (n = 5).

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TABLE 1. Studies that reported salinities tolerated by Mel-anoides tuberculatus (in situ and in the laboratory).

References

Barroso & Matthews-Cascon, 2009
Englund et al., 2000
Roessler et al., 1977
Vogler et al., 2012
Wingard et al., 2008

Sites Salinity

In situ 30
In situ 34
In situ 30
In situ 33
In situ 6)

Barroso & Matthews-Cascon, 2009 Laboratory 35
Bolaji et al., 2011
Wingard et al., 2008

DISCUSSION

According to Plaziat & Youris (2005), M. tuberculatus is an euryhaline species that inhabits low-salinity environments (0.2—3) but is capable of tolerating high salinities (over 23). Several studies are in agreement with the findings of this group and have suggested that M. tuberculatus is able to withstand salini-ties higher than 30 (Table 1), not only under laboratory conditions but also in situ. This high tolerance together with the uniparental reproduction of this organism may facilitate its invasion in new environments (e.g., estuaries) (Facon et al., 2008).
Barroso & Matthews-Cascon (2009) have demonstrated the presence of M. tuberculatus in situ in high densities in salinities ranging from 0—30; in the laboratory, this organism remained active between salinities of 25 and 35. Other studies have shown similar results, and the highest salinity inhabited by this organism was reported to be between 30 and 34 in situ (Roessler et al., 1977; Englund et al., 2000; Wingard et al., 2008; Vogler et al., 2012) and between 25 and 45 in the laboratory (Wingard et al., 2008; Bolaji et al., 2011). Therefore, M. tuberculatus can occur in high densities in hy-perhaline conditions, demonstrating its ability to adapt to euryhaline conditions. Melanoides tuberculatus is frequently ob-served in high densities, which likely increases competition for space and food between exotic and native species (Fernandez et al., 2001; Vogler et al., 2012; Wingard el al., 2008). Although this species is naturally occurring in freshwater environments, our experiment showed that it can adapt to the gradual and abrupt increases in salinity common in typical marine and hyperhaline environments. Thus,

Laboratory 25
Laboratory 45

this invasive species may cause ecological harm not only in freshwater but also in brackish water (estuaries and mangroves), especially in systems with high organic contents and limited water and flow (Giovanelli et al., 2005). Melanoides tuberculatus has been previ-ously reported in freshwater systems in north-east Brazil (e.g. Paz et al., 1995; Barroso & Matthews-Cascon, 2009; Santos & Eskinazi-Sant Anna, 2010; Souto et al., 2011; Silva & Gomes, 2014). However, there have been no reports of its potential invasion of estuaries or of its effects on native benthic communi-ties. Therefore, there is an urgent need for experimental studies to properly understand the potential negative effects of this invasive species on natural benthic assemblages.

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